

3.3.9 Weather - Severe Thunderstorms, Hail, Wind and Tornadoes

3.3.9.1 Background

A **severe thunderstorm** is a thunderstorm which produces tornadoes, hail 0.75 inches or more in diameter, or winds of 50 knots (58 mph) or more. Structural wind damage or damaged crops may imply the occurrence of a severe thunderstorm. A thunderstorm is approaching severe levels when it contains winds of 35 to 49 knots (40 to 57 mph) or hail ½-inch or larger but less than ¾-inch in diameter. Although not considered "severe", lightning and heavy rain can also accompany thunderstorms.

A **chinook** is a warm wind that develops down the east slopes of the Rocky Mountains. At times, these winds can reach several hundred of miles into the high plains.

High winds can also occur with strong pressure gradients or gusty frontal passages. These winds can affect the entire state with wind speeds in excess of 75-100 mph. Combined with snowfall or snow on the ground, high winds can cause blizzard conditions.

A **tornado** is a violently rotating column of air in contact with the ground and extending from the base of a thunderstorm. Tornadoes are categorized by the Fujita scale based on the tornado's wind speed (**Table 3.3.9-1**).

Table 3.3.9-1 Fujita Tornado Damage Scale. Source: Storm Prediction Center, NOAA, 2004d.

Scale	Wind Estimate* (mph)	Typical Damage
F0	<73	Light Damage - Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate Damage - Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable Damage - Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe Damage - Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating Damage - Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large projectiles generated.
F5	261-318	Incredible Damage - Strong frame houses leveled off foundations and swept away; automobile-sized projectiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

***Important Note About F-Scale Winds:** These precise wind speed numbers are actually guesses and have never been scientifically verified. Different wind speeds may cause similar-looking damage from place to place -- even from building to building. Without a thorough engineering analysis of tornado damage in any event, the actual wind speeds needed to cause that damage are unknown.

A thunderstorm is formed from a combination of moisture, rapidly rising warm air, and a force capable of lifting air, such as a warm and cold front or a mountain. All thunderstorms contain lightning. Thunderstorms may occur singly, in clusters, or in lines. Thus, it is possible for several thunderstorms to affect one location in the course of a few hours. Some of the most severe flooding from a thunderstorm occurs when a single thunderstorm affects one location for an extended time.

At any given moment, nearly 1,800 thunderstorms are in progress over the surface of the earth. On average, there are 100,000 thunderstorms each year in the U.S. Approximately 1,000 tornadoes develop from these storms. Straight-line winds are responsible for most thunderstorm damage.

Large hail results in nearly \$1 billion in damage annually to property and crops in the U.S. Flash floods cause an average of 146 deaths each year in the U.S with lightning killing an additional 75 to 100 people on average.

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm and the earth's surface. When the buildup becomes strong enough, lightning appears as a "bolt". This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning reaches a temperature approaching 50,000 degrees Fahrenheit in a split second. The rapid heating and cooling of air near the lightning causes thunder.

Lightning's electrical charge and intense heat can electrocute on contact, split trees, ignite fires, and cause electrical failures. Approximately 10,000 forest fires are started each year by lightning, including dry thunderstorms common to Montana each summer. Approximately **\$100 million** in annual losses result from forest and building fires caused by lightning.

Sources: TPO, 2004; NWS, 2004; FEMA, 2004c; Curran et. al, 1995.

3.3.9.2 History of Severe Thunderstorms, Hail, Wind and Tornadoes in Montana

The recording of weather events is highly dependent upon the public's observations and reporting to the National Weather Service (NWS). While weather stations are used to document wind speeds and precipitation, the spotting of tornadoes and assessment of hail stone size is often recorded based on a person's observations. These observations may be more accurate in populated areas where weather stations and other observations can verify extreme events. Rural areas may go under reported because of the fewer people that observe or witness the events. Reporting of extreme events may have also increased in the last 10 years because of better means to communicate storm events to the National Weather Service. As a result, records of storm events may indicate more frequent storms in recent history than in the past, a greater number of reports in populated areas versus rural areas, and more recent recording and documentation of losses related to severe thunderstorms

In Montana, most of the tornadoes occur in June, followed closely by the month of July. From 1950 to 1995, Montana had an annual average of 6 tornadoes. From 1950-2003, 95 of the 394 recorded tornado and funnel cloud events in Montana were considered F1 speeds or greater as recorded by the National Weather Service (2004) (**Table 3.3.9-1**). Montana had 5 deaths and at least 68 injuries from tornadoes from 1883 to 1993 (**Table 3.3.9-2**). The National Weather Service database indicates that from 1950 to 2004, severe summer weather has caused **\$59,552,000** in property damage and **\$8,345,000** in crop damage (**Table 3.3.9-3**).

Six deaths and 16 injuries were attributed to lightning strikes in Montana between 1950 and 2003 (**Table 3.3.9-3**). Based on historical storm data, hail and damaging winds are more likely to occur in Montana between 6:00 and 7:00 pm.

Table 3.3.9-2 Tornadoes causing at least one death or three injuries in Montana (1883 to 2003). Source: TPO, 2004, NOAA 2004b.

Date	Event	Deaths	Injuries
May 15, 1883	Homes and other buildings destroyed at a mining community, eight miles south of Butte.	0	6
June 10, 1923	Two men killed by a falling tree as a tornado hit a copper mine near Rivulet in Mineral County.	2	0
June 15, 1924 2:30 pm	Three homes destroyed at a farming community northwest of Great Falls.	0	7
July 4, 1927 3:30 pm	Barns destroyed and livestock killed eight miles southwest of Suffolk, Fergus County.	0	6
May 22, 1933 6:00 pm	Ten buildings destroyed in Bainville, Roosevelt County. The injuries were in a cafe.	0	12
May 8, 1934 6:30 pm	A dozen homes unroofed and two service stations destroyed at Plentywood, Sheridan County.	0	7
June 27, 1936 2:30 pm	Seven injured by an F1 tornado in Blaine County.	0	7
June 7, 1946 2:00 pm	One killed and one injured by an F3 tornado in Roosevelt County.	1	1
September 16, 1946 5:15 pm	A small home destroyed near Sidney, Richland County.	0	8
July 19, 1952 3:30 pm	A large farm near the North Dakota border completely destroyed in Wibaux County.	1	2
July 10, 1965 5:15 pm	An F1 tornado injured 5 and caused \$2.5 million in property damage in Choteau County.	0	5
July 9, 1983 6:37 pm	As the tornado passed near Vida, McCone County, it threw a car, with two people, for 200 yards.	1	1
July 20, 1993 5:30 pm	Two mobile homes destroyed in Rosebud County, two miles south of Lame Deer	0	3
August 14, 1999 4:15 pm	Two miles east of Lewistown	0	3
Total		5	68

Table 3.3.9-3 NOAA Severe Weather Summary (1950-2003). Source: NOAA, 2004b.

TYPE	Dates	Number of Events	Death	Injuries	Property Damage	Crop Damage
Dry Microbursts	1995-2002	19	0	0	\$52,000	\$0
Dust Storms	1994-2002	2	1	8	\$50,000	\$500,000
Tornadoes (F1 or greater)	1950-2003	95	2	23	\$23,118,000	\$130,000
Hail (2 inches in diameter or greater)	1950-2003	270	0	2	\$4,333,000	\$1,425,000
Significant Lightning Events	1950-2003	34	6	16	\$1,211,000	\$3,000
Winds Events with at least one death	1950-2003	4	6	5	\$260,000	\$0
Wind Events with Recorded Property Damage	1950-2003	261	1	13	\$30,528,000	\$6,287,000
Total			16	67	\$59,552,000	\$8,345,000

3.3.9.3 Declared Disasters from Severe Thunderstorms, Hail, Wind and Tornadoes

Disaster declarations for tornado and extreme wind and hailstorm events are shown in Table 3.3.9.4. No federal declarations have been made strictly for these categories of storms.

Table 3.3.9-4 Montana Disaster Declarations from Thunderstorms, Hail, Wind and Tornadoes (1974-2003). Source: MDES, 2003.

Date	Event	Damages
July 23, 1997	Windstorm (EO 14-97). Disaster declaration for the City of Libby.	State: \$56,549 Local: \$6,434
Sept. 5, 1997	Windstorm (EO 16-97). Disaster declaration for the City of Wolf Point.	State: \$13,833 Local: \$3,994
June 23, 1999	Windstorm/Tornado (EO 7-99). Disaster declaration for the Town of Opheim.	State: \$10,366 Local: \$296
August 14, 1999	Windstorm/Tornado (EO 11-99). Disaster declaration Fergus County and the City of Lewistown.	State: \$298,609 Local: \$11,544

3.3.9.4 Vulnerability to Severe Thunderstorms, Hail, Wind and Tornadoes

3.3.9.4.1 Statewide Vulnerability to Severe Thunderstorms, Hail, Wind and Tornadoes

In the case of severe thunderstorms, hail, wind, and tornadoes, the location and frequency of previous events are probably the best determiners of future events. Concentrations of these recorded events identify patterns of where they may likely occur in the future.

Table 3.3.9-5 shows the five counties with the highest frequency of tornadoes (F0 or greater as recorded from 1950 through 2003), hail events 2" in diameter or greater (1950-2003), synoptic wind events of 75 mph or greater (1993-2003) and thunderstorm winds 75 mph or greater (1993-2003). The patterns of occurrence across the state for these events are shown on **Figures 3.3.9-1, 3.3.9-2, and 3.3.9-3.**

Table 3.3.9-5 Counties with High Frequency of Tornadoes, Wind, and Hail Events. Source: NCDC, 2004

Tornadoes (≥ F0)		Hail (≥2" diameter)		Synoptic Wind (≥ 75 mph)		Thunderstorm Wind (≥ 75 mph)	
County	#	County	#	County	#	County	#
Valley	33	Powder River	17	Glacier	34	Valley	14
Fergus	21	Yellowstone	16	Pondera	24	Yellowstone	9
Yellowstone	16	Valley	15	Park	22	Garfield	8
Choteau	14	Fergus	15	Teton	21	Roosevelt	7
Cascade	13	Rosebud	13	Blaine	12	Cascade	6
Dawson	13					Choteau	6
Powder River	13					Phillips	6
						Rosebud	6

Vulnerability to wind, hail, and tornado events can be measured as a function of the frequency and potential for property damage. Historic data on occurrence and estimated damages were compiled from National Weather Service records and provided through the National Climatic Data Center (NCDC, 2004). Because hail, wind, and tornado events are often related, the frequency of a potentially damaging event was calculated for each county

in any given year. For example, if the frequency is 200%, the county will have, on average, a potentially damaging event twice each year. The frequency for each type of event was summed to provide a relative risk by county. The counties with summed frequency in excess of 100% are listed in **Table 3.3.9-6** and shown on **Figure 3.3.9-4**.

Table 3.3.9-6 Composite Storm Index for Ten Counties with Highest Vulnerability to Tornado, Extreme Wind, and Hail damage.

COUNTY	Hail Frequency	Tornado Frequency	Thunderstorm Wind Frequency	Synoptic Wind Frequency	Summary of Frequency
Glacier	0.00%	3.77%	20.00%	340.00%	363.77%
Pondera	7.55%	0.00%	20.00%	240.00%	267.55%
Teton	9.43%	7.55%	40.00%	210.00%	266.98%
Valley	28.30%	62.26%	140.00%	30.00%	260.57%
Park	0.00%	0.00%	10.00%	220.00%	230.00%
Fergus	28.30%	39.62%	40.00%	90.00%	197.92%
Yellowstone	30.19%	30.19%	90.00%	30.00%	180.38%
Cascade	15.09%	24.53%	60.00%	80.00%	179.62%
Blaine	5.66%	3.77%	50.00%	120.00%	179.43%
Garfield	16.98%	18.87%	80.00%	20.00%	135.85%
Chouteau	13.21%	26.42%	60.00%	20.00%	119.62%
Phillips	11.32%	20.75%	60.00%	20.00%	112.08%
Roosevelt	9.43%	22.64%	70.00%	10.00%	112.08%
Dawson	11.32%	24.53%	50.00%	20.00%	105.85%
Rosebud	24.53%	16.98%	60.00%	0.00%	101.51%

Source: NCDC, 2004. Events of record from 1950 to 2003 for hail (.2" diameter or greater) and tornadoes (F0 and greater). Thunderstorm and synoptic wind events 75 mph or greater from 1993 through 2003.

3.3.9.4.2 Review of Potential Losses in Local PDM Plans

Of the 6 counties that have completed Pre-Disaster Mitigation Plans, all identified tornado, extreme wind, and hailstorms as a hazard. None identified these as major hazards or within the top three hazards of the county.

3.3.9.4.3 Vulnerability of State Property

State property that has suffered damage from extreme wind, hail, or thunderstorms is shown in **Table 3.3.9-7**. The claim record was only available for the period of July 1, 1999 through June 10, 2004.

Table 3.3.9-7 Loss Claims for State Facilities Caused by Extreme Weather (Hail and Wind).

Claim ID	Agency	Location	Cause of Loss	Date of Loss	Request	Indemnity
P-11706	Transportation	Havre	Extreme Weather-Hail	6/8/2000		
P-13422	University System	Bozeman	Extreme Weather-Hail	6/30/2001	\$4,077	
P-13283	Fish, Wildlife & Parks		Extreme Weather-Hail	7/22/2001	\$2,200	
P-14519	University System	Bozeman	Extreme Weather-Hail	8/22/2002		
P-15612	Commerce		Extreme Weather-Hail	6/20/2003		
P-15292	Commerce		Extreme Weather-Hail	6/20/2003		
P-14176	Administration		Extreme Weather-Hail	1/6/2004		\$45,489
I-8334	Fish, Wildlife & Parks		Extreme Weather-Wind	7/24/1999		\$1,700
P-8163	Multiple Agencies		Extreme Weather-Wind	8/14/1999	\$150,000	\$150,992
P-9152	Multiple Agencies		Extreme Weather-Wind	10/31/1999	\$10,000	\$42,404
P-11581	University System	Bozeman	Extreme Weather-Wind	6/8/2000		\$6,687
P-11637	University System	Bozeman	Extreme Weather-Wind	7/3/2000	\$1,000	\$16,220
P-11867	University System	Bozeman	Extreme Weather-Wind	9/1/2000		\$12,704
P-12965	University System	Bozeman	Extreme Weather-Wind	4/20/2001		\$24,651
P-13470	Corrections	Miles City	Extreme Weather-Wind	7/1/2001		
P-13201	Education	Great Falls	Extreme Weather-Wind	7/12/2001		
P-13548	University System	Bozeman	Extreme Weather-Wind	7/28/2001	\$1,533	\$533
P-13078	Corrections	Deer Lodge	Extreme Weather-Wind	10/16/2001		\$20,637
P-13975	Livestock		Extreme Weather-Wind	4/14/2002		
P-14174	Corrections	Miles City	Extreme Weather-Wind	7/8/2002		
P-14603	University System	Missoula	Extreme Weather-Wind	7/12/2002		\$11,215
P-14209	Transportation	Lewistown	Extreme Weather-Wind	7/14/2002		
P-14183	Transportation	Missoula	Extreme Weather-Wind	7/15/2002		\$6,059
P-14455	Corrections	Miles City	Extreme Weather-Wind	8/16/2002		\$650
P-14329	Fish, Wildlife & Parks		Extreme Weather-Wind	8/16/2002		
P-14327	Fish, Wildlife & Parks		Extreme Weather-Wind	8/16/2002		
P-15346	Fish, Wildlife & Parks		Extreme Weather-Wind	6/18/2003		
P-15248	University System	Havre	Extreme Weather-Wind	6/20/2003		-\$435,066
P-15331	Transportation	Missoula	Extreme Weather-Wind	7/7/2003		
P-15607	University System	Bozeman	Extreme Weather-Wind	9/12/2003	\$11,800	
P-15765	University System	Butte	Extreme Weather-Wind	10/28/2003		
P-15739	Education	Great Falls	Extreme Weather-Wind	11/19/2003		
P-15693	University System	Butte	Extreme Weather-Wind	11/19/2003		

State-owned buildings that are considered to be highly vulnerable to tornadoes and extreme wind and hail events are those in counties that have a high frequency of the combined events. **Table 3.3.9-5** identifies the 10 counties with the greatest frequency of storms based on a matrix combining all types of tornado, wind, and hail storms. Those counties with highest vulnerability are considered those with a composite index greater than 200 or the counties that have had 4 or more recorded F1 or greater tornadoes. **Table 3.3.9-8** lists the counties and the State-owned facilities within those counties that are considered highly vulnerable to tornadoes, wind, and hail events.

Table 3.3.9-8 State Building Values in Counties Highly Vulnerable to Tornadoes, Wind and Hail Events (State-Owned Building/Content value in dollars)

County	Frequency	Building Value	Contents Value	Total Value	FTEs
Glacier	363.77%	\$1,677,059	\$768,958	\$2,446,017	42
Pondera	267.55%	\$827,944	\$393,099	\$1,221,043	15
Teton	266.98%	\$820,587	\$304,376	\$1,124,963	20
Valley	260.57%	\$3,651,199	\$1,318,720	\$4,969,919	58
Park	230.00%	\$2,063,368	\$847,125	\$2,910,493	48
Fergus	197.92%	\$11,239,235	\$4,069,641	\$15,308,876	570
Yellowstone	180.38%	\$186,086,741	\$73,387,683	\$259,474,424	1,192
Cascade	179.62%	\$40,483,127	\$14,585,089	\$55,068,216	593
Blaine	179.43%	\$1,407,474	\$565,954	\$1,973,428	11
Garfield	135.85%	131,779	67,821	199,600	3
Chouteau	119.62%	2,741,572	280,063	3,021,635	13
Phillips	112.08%	2,340,423	1,116,871	3,457,294	11
Roosevelt	112.08%	6,051,187	2,088,421	8,139,608	56
Dawson	105.85%	15,535,084	3,655,067	19,190,151	197
Rosebud	101.51%	855,465	229,621	1,085,086	23
Totals		\$275,912,244	\$103,678,509	\$379,590,753	2,649

From PCIIS database (2004), Montana Department of Administration, Risk Management & Tort Defense Division.

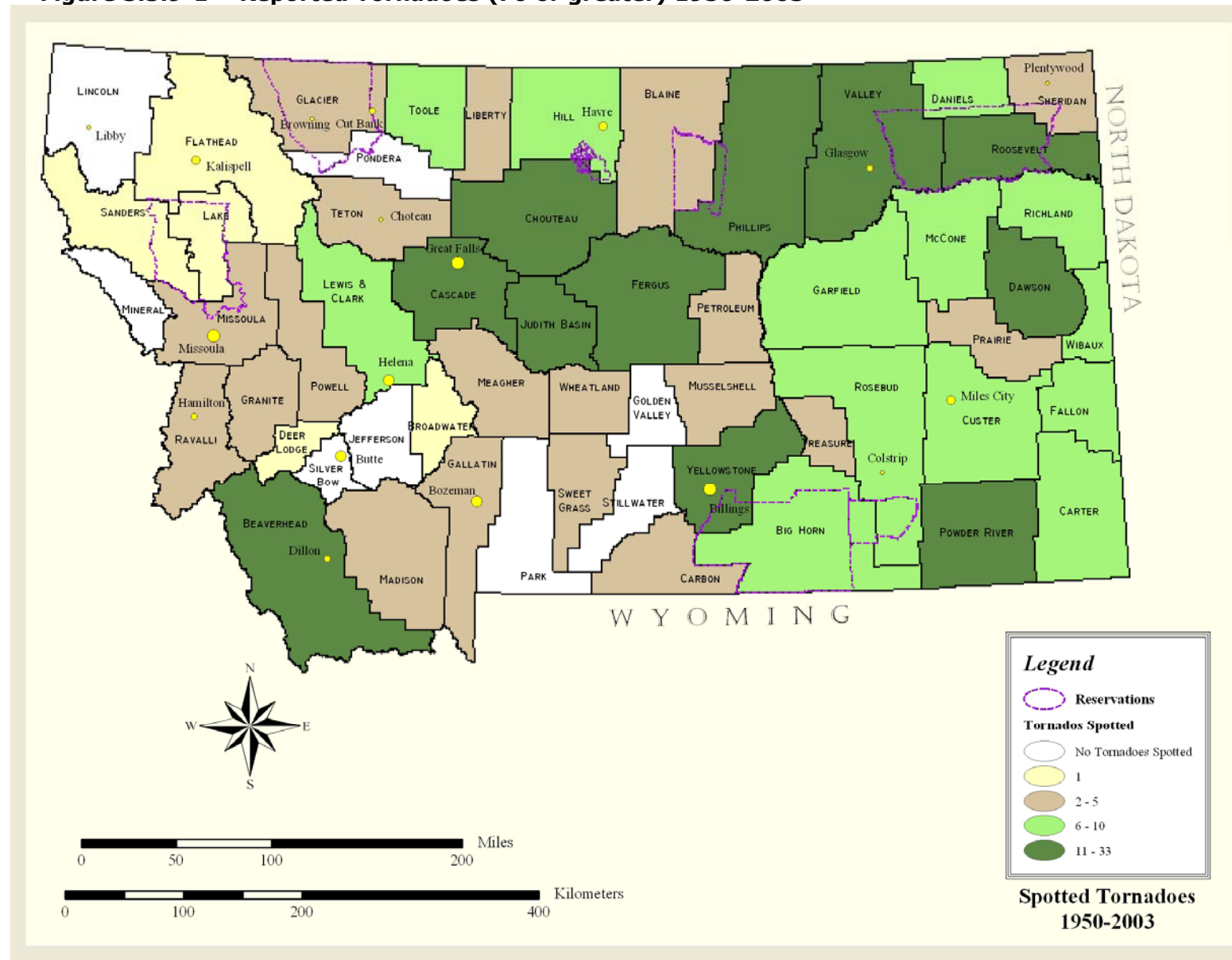
Figure 3.3.9-1 Reported Tornadoes (F0 or greater) 1950-2003

Figure 3.3.9-2 Hail Reports of 2 Inches or Greater

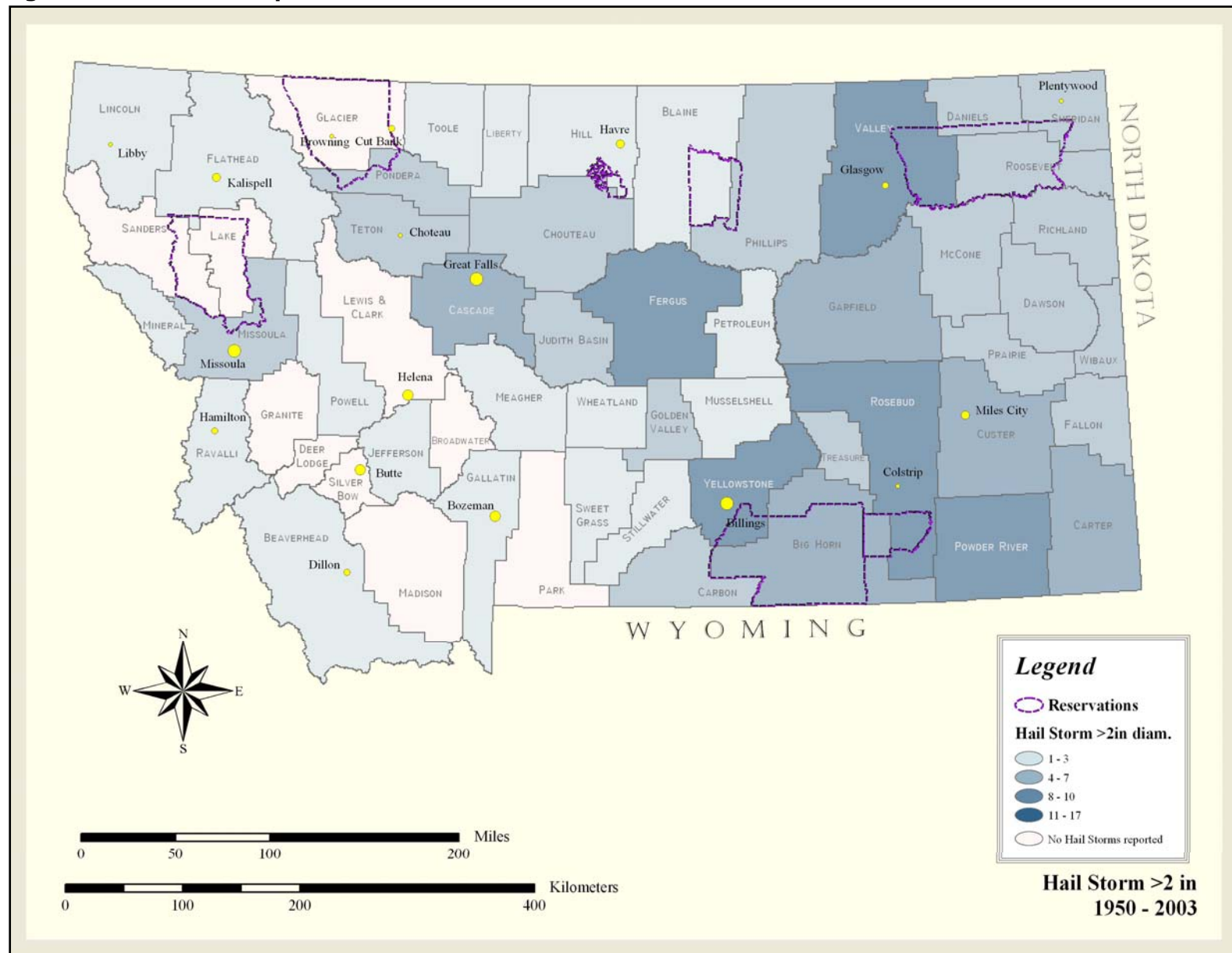


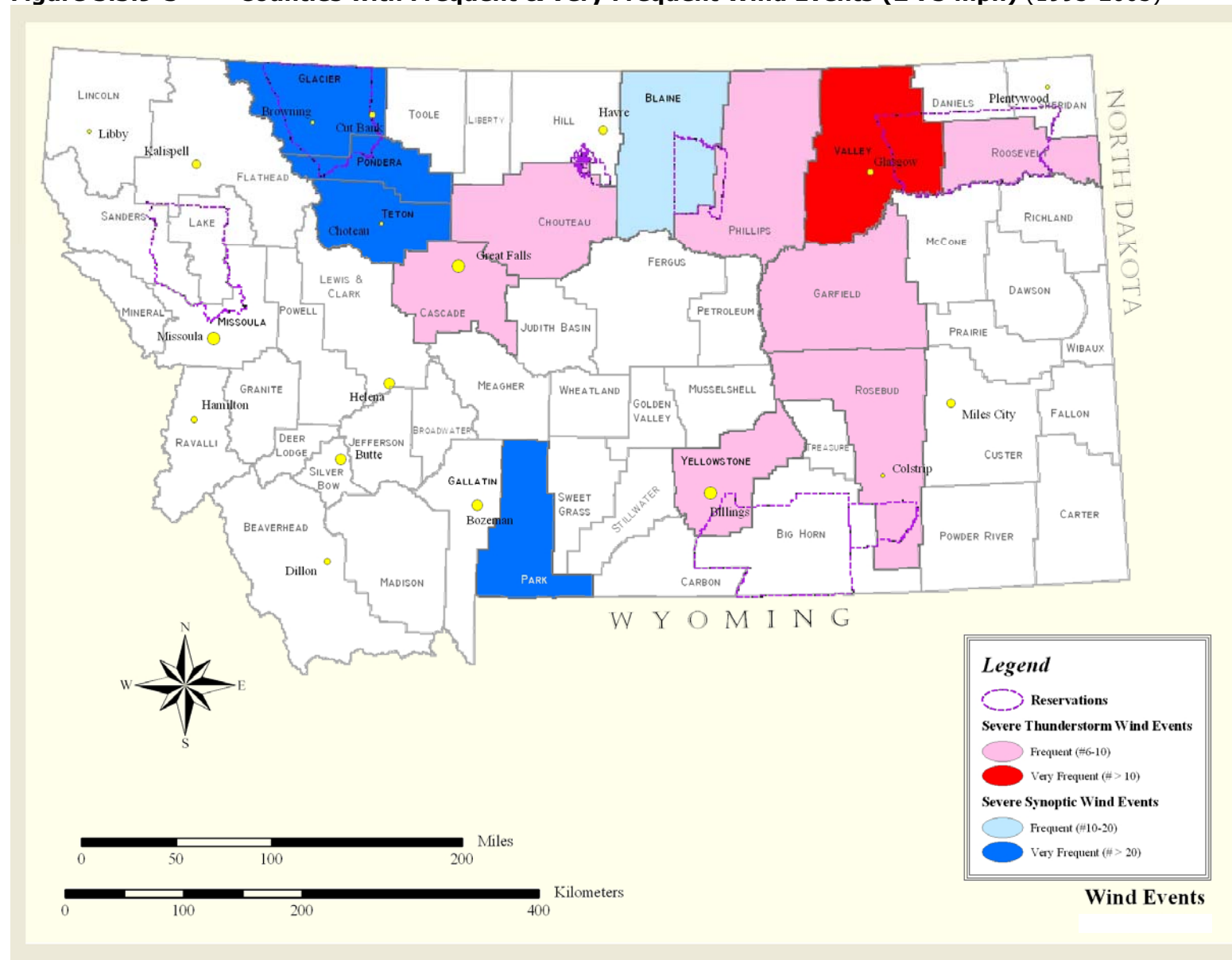
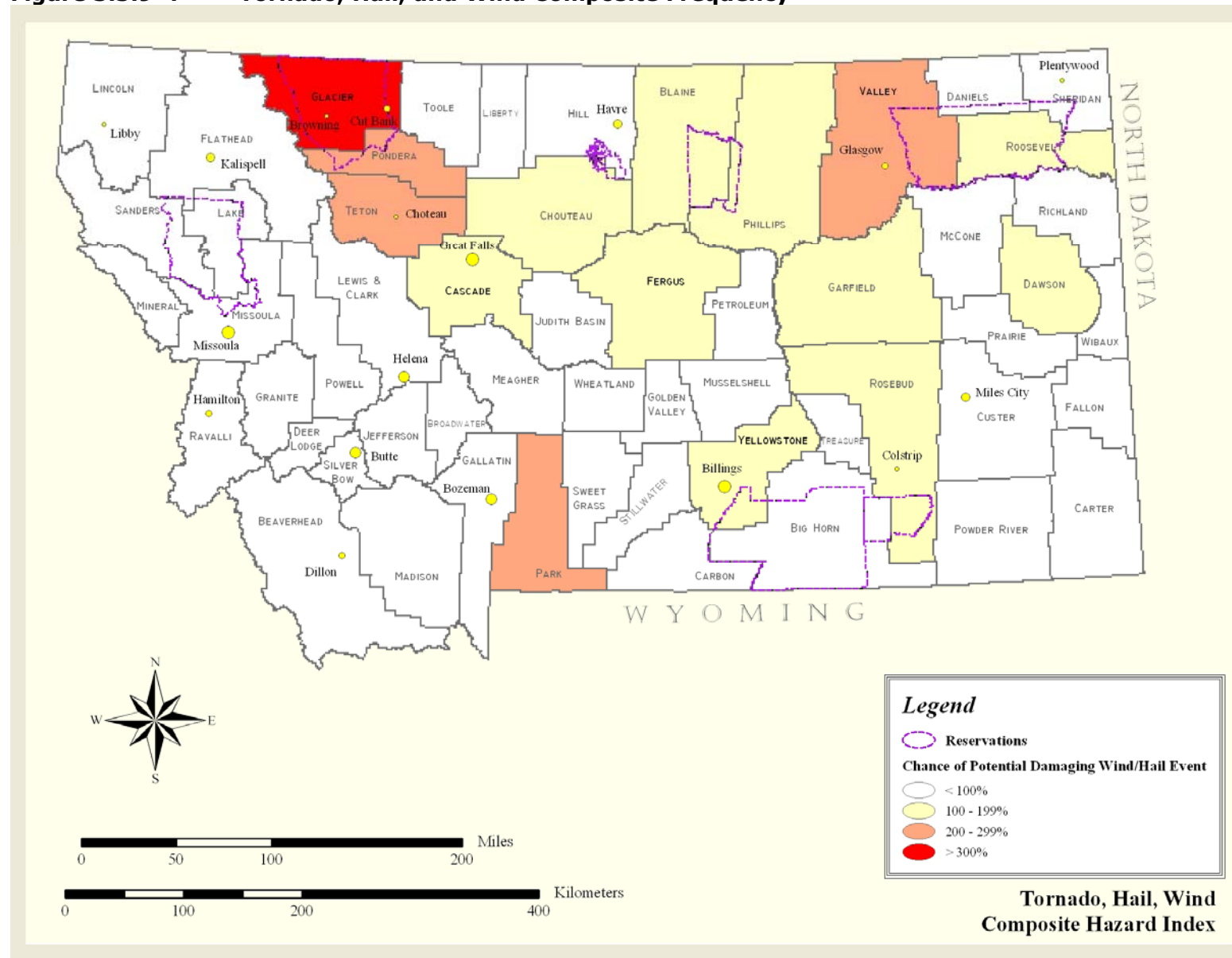
Figure 3.3.9-3 Counties with Frequent & Very Frequent Wind Events (≥ 75 mph) (1993-2003)

Figure 3.3.9-4 Tornado, Hail, and Wind Composite Frequency



3.3.9.5 Severe Thunderstorms, Hail, Wind and Tornadoes Data Limitations

To effectively determine vulnerability of State property, data identifying locations of State buildings is necessary. The current PCIIS building database is not geo-referenced and cannot be effectively related to spatial coordinates except in general locations (by city or zip code centroid). In addition, the year built and structural stability are additional factors that would assist in assessing the vulnerability to state buildings.

National Weather Service (NWS) data has improved significantly in the past decade, however, events are typically only recorded if observed by a weather station or reported to the local NWS office. In a state as rural as Montana, the data will therefore be somewhat dependent on event location (in a populated area versus an unpopulated area) and limited in that respect.

3.3.9.6 Severe Thunderstorms, Hail, Wind and Tornadoes References

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